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**Battery of bipolar stack design, and method for its
production**

The invention relates to a battery for the electrochemical storage of energy in bipolar stack design, in accordance with the preamble of Claim 1, and to a method for its production in accordance with the preamble of Claim 27.

The invention relates in particular to the structure and method of operation of an electrochemical battery of this type.

Alkaline storage batteries with a type of electrode which has become known as a fibrous-structure framework electrode have been in existence for about 15 years. Electrodes of this type and methods for their production are described, for example, in DE 40 40 017 C2, DE 41 03 546 C2, DE 38 22 197 C1, DE 40 04 106 C2, DE 39 35 368 C1, DE 36 32 351 C1, DE 36 32 352 C1, DE 41 04 865 C1 and DE 42 25 708 C1.

By way of example, DE 40 04 106 C2 reveals a fibrous structure framework electrode with a high load-bearing capacity, DE 38 22 197 C1, DE 40 40 017 C2 and DE 41 03 546 C2 reveal methods for filling fibrous structure framework electrodes for storage batteries with an active-compound paste.

Conventional storage batteries comprise individual galvanic elements which are composed of individual electrodes of different polarity, the electrolyte, the separator between the electrodes, the cell or battery casing and the current-carrying and other passive components.

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A bipolar stack design differs from the conventional structure in that the connectors between the individual cells and the separate cell casings are dispensed with, and the electrochemical elements, which are referred to as subcells, are connected in series by conductive partitions.

Each subcell has a positive electrode, a separator and a negative electrode, the two electrodes being separated by the electrolyte-filled separator.

Between each pair of subcells there is a connecting wall which is responsible both for electrolytic separation of the subcells and for electrical conduction or contact perpendicular to the surface between the positive and negative electrodes, the current flowing transversely with respect to the electrodes.

For this purpose, the mutually facing surfaces of the connecting wall, on the one hand, and the corresponding positive or negative electrode, on the other hand, touch one another as a result of the connecting wall making contact with the electrodes over a large area under a pressure which is predetermined but changes slightly in operation. Consequently, there are short paths for the electric current. A structure of this type increases the specific energy, since the high consumption of material for the current discharge is minimized. This is because the inactive components, such as at least the current discharge lugs for each individual electrode and the pole bridges to which the current discharge lugs are attached, which are otherwise required to conduct electric current, are eliminated.

The diagrammatic bipolar structure and the method of operation of a multicell battery in pile form is described, for example, in the Batterie Lexikon by Hans-Dieter Jaksch, Pflaum-Verlag, Munich, p. 442. By way of example, metal or an electrically conductive polymer is known for the connecting wall; when using metallic connecting walls, nickel plates or nickel-coated steel plates are recommended for alkaline aqueous systems.

Therefore, it is an object of the present invention to provide a battery of bipolar stack design, in which, in operation, uniform loading of the individual subcells is possible. Furthermore, it is intended to provide a method for producing a battery of this type.

The solution consists in a battery having the features of Claim 1 and in a method having the features of Claim 27. According to the invention, it is provided that the electrodes, the separators and the connecting walls are in the form of plates or discs, that the battery comprises a stack of individual plates or discs, the pairs of positive and negative electrodes, together with separator layers and connecting walls, being stacked and electrical contact being formed only by pressing the individual plates or discs onto one another, the negative electrode only being coated with the active material from one side, and the positive electrode, on the contact side, being substantially free of active compound, and all the subcells having a common gas space but no electrolyte contact.

Therefore, the battery does not have the bipolar electrodes which are known from the literature, but rather comprises individual electrodes as discs or plates which are stacked with separator layers and thin

disc-like connecting walls. The electrical contact is formed only as a result of the pressure exerted on the parts. It is expedient to ensure that metallic parts without insulating layers come into contact with one another and the connecting wall is clean. Furthermore, electrical contact can be improved by additions which increase the conductivity.

In particular, the battery according to the invention has a gas space which is common to all the electrodes or cells. The gas connection between the subcells produces, in accordance with the invention, a battery whose individual components are subject to uniform mechanical and electrical loads. Consequently, all the subcells are under the same gas pressure and the same surface pressure. Furthermore, it is possible to compensate for the hydrogen loading and the electrolyte concentration along the individual electrodes. The heat tone of the reactions at the electrodes also effects temperature compensation. In the same sense, the dilution of the electrolytes of the individual subcells is also compensated as a result of the transfer of water in gaseous form. A further advantage is that only a single pressure-relief/safety valve is required, on account of the common gas space.

These features according to the invention are of considerable advantage in particular in the electrochemical nickel/metal hydride system which is preferably used for the operation of the cells, since the negative electrode is in gas equilibrium with the stored reactant hydrogen in the cell and the positive electrode tends to form gas at the charge end. The advantageous balancing of the charges which has been described is limited exclusively to the nickel/metal hydride system on which the invention is based.

It is also possible to optimize the design by using a suitable configuration of the connecting cross sections of the gas leadthroughs.

Advantageous refinements will emerge from the subclaims. The connecting elements may comprise nickel plates. Their thickness is advantageously at most 0.1 mm.

The compressive force to be applied is approximately 10 to 35 N/cm². It can be set by means of elastic elements, for example spring elements. However, it can also be set by means of a rigid construction of the battery according to the invention, in which case end plates which are at a fixed distance from one another are provided.

The ability of the lye to creep along metallic surfaces in the potential field transports and irreversibly shifts the electrolyte between the cells. This would lead to the battery system failing as a result of drying out. Surprisingly, it has emerged that, by applying a hydrophobic coating, which may comprise one or more partial layers, to the edges of the metallic connecting discs, this process is effectively prevented. According to the invention, it is preferable to carry out coating by means of polytetrafluoroethylene or a bituminous substance.

During the first charging of the battery according to the invention, the positive electrode expands as a result of water and alkali being incorporated in the substrate, for example in the layer grid of the nickel hydroxide in the fibrous structure electrode framework. The negative electrode also expands as a result of

hydrogen being incorporated in the substrate material. Therefore, it is advantageous if the separators comprise an elastic nonwoven or felt which absorb compressive forces produced during the expansion of the electrodes.

A preferred design of the battery according to the invention uses a central passage, around which the stacks of electrodes, separators, and connecting walls are arranged, the stacks preferably being connected to the central passage by porous connecting elements. The subcells are in communication with the central passage through the porous connecting element, for example rings or the like made from porous polytetrafluoroethylene. A tie rod for relieving the load on the end plates may be provided in the central passage. The quantity of electrolyte can be regulated by adding liquid, that is to say water for example, by means of a tube of porous material, e.g. porous polytetrafluoroethylene, which is fitted in the central passage.

The method according to the invention for assembling a battery according to the invention provides for the individual plates to be filled with electrolyte prior to assembly and for the components then to be stacked on top of one another.

The advantages achieved with the invention reside in particular in the fact that it is possible to produce a battery which allows high loads in terms of current combined with a favourable voltage on account of the short current path. The exchange operations in the battery, as well as the electrochemical system, ensure a high use time of the battery.

The method according to the invention is distinguished by the fact that the load-bearing capacity and handling of the battery is considerably improved compared to conventional batteries.

Advantageous refinements will emerge from the subclaims.

Exemplary embodiments of the present invention are described in more detail below with reference to the drawings, in which:

Figure 1 diagrammatically depicts the design principle of a storage battery of bipolar stack design, and

Figure 2 shows a diagrammatic sectional illustration of the storage battery from Figure 1 in the form of a round stack.

The storage battery 1 of stack design, which is diagrammatically depicted in Figure 1, has a housing 2 with a negative pole 3 and a positive pole 4. In the housing 2 there is a stack of individual disc-like or plate-like separators 5, negative electrodes 6, positive electrodes 7 and connecting walls 8. All the discs 5, 6, 7, 8 or subcells formed therefrom have a common gas space 9. The stack is pressed together by spring elements (not shown), for example elastic discs, arranged on the inner wall of the housing 16. Electrical contact is produced only by the pressure. The connecting walls 8 may comprise nickel plates. Their thickness is advantageously at most 0.1 mm.

Figure 2 diagrammatically depicts a longitudinal section through another embodiment 10 of the battery

according to the invention. The disc-like or plate-like separators 5, electrodes 6, 7 and connecting walls 8 are now round and have a central passage 12 which is designed as a central bore in the plates or discs 5, 6, 7, 8 and is closed off, for example, using a screw. The stack is enclosed fixedly in a housing 16, two end plates 14, 15 being provided, which are at a fixed distance from one another and provide the pressure. The end plates 14, 15 may be part of the housing 16 or may also be separate and surrounded by the wall of the housing 16. The stack is centred by means of O-rings which are arranged along the wall of the housing 16 and between in each case two connecting walls 8. They may consist of a porous material or of a material which promotes heat transfer between the plates or discs, for example neoprene. The common gas space 9 is formed by the central passage 12. It is advantageously also possible, for example, to top up electrolyte liquid via the central passage 12. The central passage 12 is designed in particular as a porous tube 13 made from polytetrafluoroethylene. As an alternative to the tube 13, it is also possible to use rings of porous material. The poles 3, 4 are situated on the top side and under side, respectively, of the housing 16. The pole plate provided may, for example, be a combination of nickel and honeycomb bodies made from plastic or aluminium with a high flexural strength.

In this design variant with fixed distance between the end plates, the pressure required to make contact is predetermined during construction and rises during the initial loading as a result of the expansion of the electrodes 6, 7. Since the electrodes are in practice not compressible, the separator 5, which preferably consists of an elastic material, acts as the spring.